SECTION 13000
TENSILE MEMBRANE STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes exterior architectural tensile membrane canopy structure systems.

B. The tensile membrane structure Subcontractor shall be responsible for the design, engineering, fabrication, supply and installation of the Work specified herein. The intent of this specification is to establish an undivided, single-source responsibility for the above functions.

C. The Subcontractor's Work shall include, but not necessarily be limited to, the supply, fabrication, shipment, and erection of the following principal items.
   1. The architectural membrane as indicated on the drawings and in these specifications.
   2. Cables and end fittings.
   3. Perimeter, catenary, and sectionalized aluminum clamping system.
   4. Structural steel, including masts, struts, beams, and/or weldments, as indicated on the drawings.
   5. Fasteners and gasketing.

1.2 REFERENCES

A. General: Except as otherwise shown or noted, all Work shall comply with the requirements of the following codes and standards.
   1. Standard Building Code of Southern Building Code Congress International (SBCCI).
   2. American Institute of Steel Construction (AISC).
      a. Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings.
      b. Code of Standard Practice for Steel Buildings and Bridges.
      c. Specification for Structural Steel Buildings – Allowable Stress Design and Plastic Design.
      d. Specification for Allowable Stress Design of Single-Angle Members.
      e. Seismic Provisions for Structural Steel Buildings.
   3. American Society of Civil Engineers (ASCE).
      a. ASCE 19: Structural Applications of Steel Cables for Buildings.
   4. American Society for Testing and Materials (ASTM).
      a. ASTM A603: Standard Specification for Zinc-Coated Steel Structural Wire Rope.
      b. ASTM A416: Standard Specification for Uncoated Seven Wire Stress Relieved Strand for Prestressing Concrete.
      c. ASTM A586: Standard Specification for Zinc-Coated Steel Structural Strand.
      d. ASTM A603: Standard Specification for Zinc-Coated Steel Structural Wire Rope.
      e. ASTM D4851: Standard Test Methods for Coated and Laminated Fabrics for Architectural Use.
      f. ASTM E84: Standard Test Method for Surface Burning Characteristics of Building Materials.
      g. ASTM E108: Standard Test Methods for Fire Tests of Roof Coverings.
      h. ASTM E136: Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 Degrees C.
      i. ASTM E424: Standard Test Method for Solar Energy Transmittance and Reflectance of Sheet Materials.
   5. American Welding Society (AWS).
      a. AWS D1.1: Structural Welding Code.
      b. AWS 2.4: Symbols for Welding and Nondestructive Testing.

6. Aluminum Association.
   a. Specifications for Aluminum Structures.
7. National Fire Protection Association (NFPA).
   a. NFPA 701: Standard Methods of Fire Tests for Flame-Resistant Textiles and Films.
8. Steel Structures Painting Council (SSPC).
   a. Steel Structures Painting Manual, Volumes 1 and 2.

1.3 SYSTEM PERFORMANCE REQUIREMENTS

A. General: Provide a structural tensile membrane system that complies with performance requirements specified herein by testing the Subcontractor's corresponding PTFE-coated fiberglass tensile membrane system in accordance with the indicated test methods.

B. Structural Design Criteria: The tensile membrane structure shall be designed to comply with the Standard Building Code.

C. Life Safety: All tensile membrane structures shall be designed so that no life safety issue is created in the event of a loss of a part of the membrane. The tensile membrane structure shall not rely on the membrane for structural stability.

D. Fire Performance: Range of characteristics required of PTFE-coated fiberglass membranes:

1.	Burning Characteristics (ASTM E84).	
	a. Flame Spread	5 max.
	b. Smoke Generation (Tunnel Test)	5 max. to 10 max.
2.	Fire Resistance of Roof Coverings (ASTM E108).	
	a. Spread of Flame	Class A
	b. Intermittent Flame	Class A
	c. Burning Brand	Class A
3.	Incombustibility of Substrates (ASTM E136).	
	a. Substrate Noncombustible	Pass
4.	Flame Resistance (NFPA 701 Small Scale, UL 94).	
	a. Flame Out	1 second after
	b. Char Length	0.25-inch max.

1.4 QUALITY ASSURANCE

A. Subcontractor Qualifications: Fabrication and erection of the PTFE-coated fiberglass tensile membrane structure shall be limited to a firm with proven experience in design and construction of complex tensile membrane structures, including complying with the following minimum requirements:
   1. The Subcontractor shall have at least 15 years' experience in the engineering, fabrication, and erection of permanent, custom tensile membrane structures.
   2. The Subcontractor shall have engineered, fabricated, and erected at least 20 PTFE-coated fiberglass tensile membrane structures, with at least 5 structures of similar size and design complexity as this project.
   3. The Subcontractor shall demonstrate that it has maintained a professional staff for at least 15 years, and will provide engineering drawings that have been prepared by Professional Engineers in its employ.
   4. The Subcontractor shall demonstrate that it has a staff of experienced tensile membrane structure installation personnel who will undertake the installation of the project.
      a. The site installation supervisor shall have a minimum of 10 years' experience supervising the erection of tensile membrane structures of similar size and complexity.
   5. The Subcontractor shall submit a Corporate Quality Control Manual describing the company's complete quality assurance program.

1.5 SUBMITTALS

A. Product Data:
   1. Include manufacturer's specifications for materials, fabrication, installation, and recommendations for maintenance.
   2. Include test reports showing compliance with project requirements where test method is indicated.

B. Samples: Submit selection and verification samples.

C. Shop Drawings: Subcontractor shall submit tensile membrane structure drawings defining the completed structure, anchorage and connection details, interfaces with building construction, and general membrane seam arrangements.
   1. Drawings shall include typical unit elevations of 1/4 IN = 1 FT and details at 1-1/2 IN = 1 FT.
   2. Include setting drawings, templates, and directions for the installation of anchor bolts and other anchorages installed as a unit of work in other sections.
   3. Indicate where and how the system deviates from contract drawings and specifications. Provide material properties and other information needed for structural analysis including computations prepared, signed, or sealed by a Professional Engineer.

D. Project information:
   1. Subcontractor's qualification data:
      a. Preliminary reaction loads imparted by the tensile membrane structure to its attachment points.
      b. Schedule indicating key milestone dates during the project.
      c. A complete construction methodology statement indicating the Subcontractor's processes and procedures for erection of the material scope of work.
      d. A complete outline of the Subcontractor's Company-Wide Safety Program.
      e. A complete outline of the Subcontractor's Corporate Quality Assurance Program.
      f. Identify the number of years the Subcontractor has been in the business of designing, engineering, fabricating, supplying and installing custom tensile membrane structures.
      g. All names under which the Subcontractor has operated and time periods during which each name was used.
      h. State in which the Subcontractor is incorporated and date of incorporation.
      i. Names of all corporate officers.
      j. Any projects on which the Subcontractor has defaulted, and complete details regarding the default.
      k. All contracts valued at over $500,000 which are currently in progress, including the project name, location, Owner, Architect, Engineer, Contractor, contract amount, date of completion and/or percentage complete.
   2. Test Reports: Provide test reports from a qualified independent testing laboratory that show compliance by the Subcontractor's PTFE-coated fiberglass tensile membrane system with performance requirements indicated, based on comprehensive testing of the system by the laboratory within the last 3 years current production of the system by the Subcontractor.
      a. Physical test data of the actual fabric roll goods to be used in the project confirming conformance with specifications for the membrane.
   3. Certificates: Product certificates signed by the Subcontractor certifying materials comply with specified performance characteristics, criteria, and physical requirements.

E. Contract closeout information:
   1. Warranty: Project Warranty documents as described herein.
   2. Record Documents: Project record documents for installed materials in accordance with Section 01720.

3. Maintenance Manual: Submit 2 copies of a maintenance manual for the tensile membrane structure to the Government. The manual shall include a schedule for routine inspection, an inspection checklist, instructions for emergency repair and use of emergency repair materials, and warranty. During the system erection period, the Government shall provide maintenance personnel to be trained in the use of the repair materials.

1.6 PRODUCT DELIVERY, HANDLING, AND STORAGE

A. Materials shall be packed, loaded, shipped, unloaded, stored, and protected in a manner that will avoid abuse, damage, and defacement.

1.7 WARRANTY

A. A project completion, the Subcontractor shall furnish the Government with a written Warranty, which warrants that the PTFE-coated fiberglass membrane, its perimeter attachment system and the structural support system as supplied by the Subcontractor has been installed in accordance with the project specifications and will be free from defects in materials and workmanship which will impair its normal use or service. The Warranty period shall extend from the date of Project Completion of the tensile membrane structure, but shall in addition include the time period before Project Completion beginning on the first day when the entire tensile membrane structure is subject to design prestress conditions.
1. 5 Year Warranty period.

PART 2 - MATERIALS

2.1 STRUCTURAL MEMBRANE

A. General: Subject to compliance with requirements, the PTFE (i.e. polytetrafluoroethylene) - coated fiberglass architectural membranes that may be incorporated in the Work include, but are not limited to, the following:
1. Sheerfill Architectural Membrane, as manufactured by Chemfab Corp. of Merrimack, NH.

B. The membrane shall meet the following general requirements:
1. Source Quality Control: The primary materials shall be obtained from a single manufacturer, and secondary materials shall be those recommended by the primary manufacturer.
2. The entire membrane shall be fabricated from one type of fabric.
3. Physical Characteristics: The following indicates a range of physical properties typical of appropriate PTFE-coated fiberglass architectural membranes. The determination of the actual characteristics and selection of a specific membrane shall be derived from project engineering.

a.	Coated Fabric Weight (oz./sq. yd.):	29 min. to 38.5 max. nom. (ASTM 4851)
b.	Thickness (mils):	22 min. to 30 max. nom. (ASTM 4851)
c.	Strip Tensile (lbs./in., avg.):	
	Dry, Warp	520 min. to 785 min. avg. (ASTM 4851)
	Dry, Fill	590 min. to 560 min. avg. (ASTM 4851)
d.	Trapezoidal Tear (lbs./in., avg.):	
	Warp	35 min. to 70 min. avg. (ASTM 4851)
	Fill	60 min. to 65 min. avg. (ASTM 4851)
e.	Solar Transmission (%, min. to max.):	12.5 to 17.5 nom. (ASTM E424)
f.	Solar Reflectance (%, min. to max.):	72.5 to 73 nom. (ASTM E424)

C. Materials.

1. Base Fabric: The yarns used shall be of the highest commercial quality, essentially free of broken fibers and fully suitable for coating. The yarns shall be constructed from continuous Beta glass filaments measuring 3.3 to 4.1 microns in diameter. The fabric shall be woven with uniform tension and crimp in the warp and fill yarns and free of defects deleterious to the coating process. The base fabric shall be of sufficient width to allow for finished coated goods of at least 150 inches.
2. Fluorocarbon Coatings: The coating materials shall be fluorocarbon resins formulated specifically for architectural applications. These materials shall be applied to form a weatherized barrier between the glass yarns and the environment. The bulk of the coating shall be comprised of formulated dispersions of DuPont's Teflon® PTFE fluoropolymer resin and additives to enhance abrasion and tear resistance, impart pigmentation or modify solar transmission. The additives shall not contribute more than 20 percent by weight of the total coating or 25 percent by weight of any individual layer. The surface shall be comprised totally of a fluoroethylenepropylene (i.e. DuPont's Teflon® FEP) resin to facilitate heat welding.
3. After weaving, the base fabric shall be cleaned and primed to achieve optimum mechanical properties of the coated membrane.
4. The coating, described above, shall be virtually free of mud cracks and pinholes.
5. Coating shall be applied evenly to both sides of the fabric and the FEP fluorocarbon resin topcoat shall be of sufficient thickness to permit proper heat fusion of joints with the recommended die pressure and temperature.

2.2 CABLES AND END FITTINGS

A. Materials.
1. Structural wire rope cables shall conform to the latest revision of ASTM A603.
2. Structural strand cables shall conform to the latest revision of ASTM A586.
3. 7 wire prestressing strand shall be grade 270 and shall conform to the latest revision of ASTM A416.
4. Cables shall be coated to "Class A" zinc coating throughout.
5. Cables in contact with the membrane shall be white PVC coated; other cables may be galvanized only.

B. Fabrication.
1. Cable fabricator shall provide effective quality control over all fabrication activities.
2. Inspection of the place of fabrication may occur at any time to verify proper quality control.
3. Inspection does not relieve the fabricator from meeting the requirements of this specification.
4. Cables that are designated to be prestretched shall be prestretched per ASTM A603 for wire rope and ASTM A586 for structural strand.
5. Cables of the same type shall have the same modulus of elasticity.
6. Cables shall be manufactured to the following length tolerances at 70 degF:
   a. Length of less than 70 feet: 1/4 IN
   b. Length 70 to 270 feet: 0.03% of length
   c. Length of more than 270 feet: 1 IN
7. Cables shall have a continuous longitudinal paint stripe (1/4 IN wide maximum) along their top surface unless noted otherwise.
8. Index markings shown shall be a circumferential paint stripe (1/4 IN wide maximum).
9. cables and end fittings shall be delivered clean and dry.
10. Swaged and speltered fittings shall be designed and attached to develop the full breaking strength of the cable.
11. Thimble end fittings shall develop a minimum of 90 percent of the cable breaking strength.
12. Swaged end fittings, pins, nuts, and washers shall be electro-galvanized.
13. Speltered end fittings shall be hot dip galvanized per ASTM A153.

14. Damage to the zinc coating shall be cleaned and painted with a gray zinc-rich paint per ASTM A780.
15. Full certification, including cable physical data, mill test reports, and reports from prestretching and end fitting testing, are required to be submitted where authorized by the Subcontractor.
16. Permanently mark all end fittings with the mark number and "X" and "Y" end designations.
17. Attach a metal tag indicating the cable length and mark number to each cable assembly.
18. Design load is the load in the cable under designed prestressed load condition.
19. Fabrication load is the load under which the length shown is to be measured for cable assembly.

2.3 ALUMINUM CLAMPING SYSTEM

A. Materials.
   1. Structural aluminum clamping systems shall be ASTM alloy 6061-T6.
   2. Bent plates shall be formed from ASTM alloy 6061 and then heat-treated to T6.
   3. Structural "U straps" shall be formed from ASTM alloy 6063 and then heat-treated to T5.
   4. Structural aluminum clamping shall have the following finish.
      a. Polyester thermosetting powder coating with a tri-glycidyl di-isocyanurate (i.e. TGDI) curing agent/hardener per American Architectural Manufacturers Association (AAMA) 605.2 to a thickness of 3 mils, white in color.
   5. Structural sheet aluminum shall be ASTM alloy 5052-H32.
   6. Non-structural sheet aluminum shall be ASTM alloy 1100 series.

B. Fabrication.
   1. Aluminum fabricator shall provide effective quality control over all fabrication activities. Inspection of the place of fabrication may occur at any time to verify proper quality control.
   2. This inspection does not relieve the fabricator from meeting the requirements of this specification.
   3. Fabricated aluminum shall have no sharp edges.
   4. Stamp all parts with the appropriate mark number.
   5. All fabricated aluminum shall be free of oil, grease, and machining chips.
   6. Tolerances shall comply as follows:
      a. Cross sectional dimensions: +/- 10%, 0.03-IN maximum.
      b. Bolt hole locations: +/- 1/32 IN
      c. Overall length: +/- 1/16 IN
   7. Welded joints shall conform to AWS D1.2.
   8. Full certification, including alloy type, heat treatment, and mechanical properties, shall be submitted.

2.4 STRUCTURAL STEEL

A. Structural steel fabrication shall comply with the latest revision of all applicable codes, standards, and regulations including the following:
   1. AISC: "Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings" and "Code of Standard Practice for Steel Buildings and Bridges".
   2. SSPC: "Steel Structures Painting Manual, Volumes 1 and 2".
   3. Research Council on Riveted and Bolted Structural Joints: "Specification for Structural Joints Using ASTM A325 or A490 Bolts".
   4. AWS D1.1 and AWS A2.4.

B. In the event of conflict between pertinent codes and regulations and the requirements of the referenced standards or these specifications, the provisions of the more stringent shall govern.

C. Materials:
   1. Structural steel for plates and bars shall conform to the requirements of ASTM A36 or ASTM A572, Grade 50, unless noted otherwise.

2. Structural pipe shall conform to ASTM A53, Types E or S, Grade B.
3. Structural tubing shall conform to ASTM A500 Grade B.
4. Structural bolts:
   a. High strength bolts: ASTM A325, unless noted otherwise.
   b. Common bolts and nuts: ASTM A307.
   c. Threaded rods: ASTM A36, unless noted otherwise.
   d. Anchor bolts: ASTM A307 non-headed type, or A36 threaded rod, unless noted otherwise.
5. Other materials: All other materials, not specifically described but required for a complete and proper installation of structural steel, shall be provided and shall be new, free from rust, and first quality of their respective kinds.

D. Accessories:
1. Base Plates and Anchor Bolts:
   a. Base plates supported on concrete, whether shop attached or shipped loose, shall be furnished and set on shims or leveling plates.
   b. Anchor bolt locations shall be furnished by the Subcontractor to set the bolts.
   c. Contractor shall verify the setting of the bolts to insure their proper positioning prior to pouring of concrete.
   d. Anchor bolts shall have 2 nuts and washers; damaged threads shall be repaired or be cut to permit full tightening of nuts.

E. Fabrication:
1. Workmanship: All members, when finished, shall be true and free of twists, bends, misalignments, rough exposed welds and open joints between the component parts. Members shall be thoroughly straightened in the shop by methods that will not injure them, before being worked on in any way.
   a. Properly mark materials, and match-mark when directed by the Subcontractor, for field assembly.
2. Connections:
   a. Connections shall comply as indicated on the drawings. When details are not shown, connections shall conform to AISC requirements.
   b. Provide high-strength threaded fasteners for all structural steel bolted connections, unless noted otherwise.
   c. Combination of bolts and welds in the same connection are not permitted, unless otherwise detailed.
   d. Welded Connections:
      1) Definitions: All terms herein relating to the welds, welding and oxygen cutting shall be construed in accordance with the latest revision of “Standard Definitions of Welding Terms and Master Chart of Welding Processes” of the AWS.
      2) Operators: Welds shall be made only by operators who have been previously qualified by tests, as prescribed in AWS D1.1 to perform the type of work required.
      3) Welding equipment shall be of sufficient capacity and maintained in good working condition, capable of adjustment in full range of current settings. Welding cables shall be adequate size for the currents involved and grounding methods shall be such as to insure proper machine operation.
      4) No welding shall begin until joint elements are clamped in proper alignment and adjusted to dimensions shown on the drawings with allowance for any weld shrinkage that is expected. No members are to be spliced without prior approval.
      5) All welding shall be done in accordance with the reference specifications, with the following modifications and additions:
         a) All field welding shall be performed by manual shielded metal-arc welding.

b) All groove welds shall have complete penetration, unless otherwise specified on the drawings.
c) The minimum preheat and interpass temperature requirements shall be as required per AWS D1.1.
d) Exposed welds shall be ground smooth and blended with adjacent surfaces to conceal connections.

6) Welding Sequence: Heavy sections and those having a high degree of restraint must be welded in a sequence with the proper preheat and post-weld heat treatment such that no permanent distortion occurs. Submit a welding sequence for approval for these types of connections.

7) Oxygen Cutting: Manual oxygen cutting shall be done only with a mechanically guided torch. Alternatively, an unguided torch may be used provided the cut is not within 1/2 IN of the finished dimension and the final removal is completed by chipping or grinding to produce a surface quality equal to that of the base metal edges. The use of oxygen-cut holes for bolted connections will under no circumstances be permitted, and violation of this clause will be sufficient cause for the rejection of any pieces in which oxygen-cut holes exist.

3. Tolerances: All tolerances shall be as per the AISC "Code of Standard Practice for Steel Buildings and Bridges".

4. Paint System:

a. Source Quality Control: Primary materials shall be obtained from a single manufacturer. Secondary materials shall be those recommended by the primary manufacturer.

b. Surface Preparation and Prime Coat.

1) The surface shall be commercially blast cleaned in conformance with SSPC-SP 6, after all fabrication operations such as machining and welding are complete.
2) No more than eight hours time shall lapse between surface preparation and the application of the prime coat.
3) Primer shall be Tnemec Series 68 Poxiprime II (Color: 1255 Beige) or approved equal, and shall conform to SSPC-Paint 22.
4) Primer shall be mixed and applied in accordance with the manufacturer's instructions and shall meet the requirements of SSPC Paint Specification No. 22.
5) The minimum dry film thickness shall be 3.0 to 5.0 mils.

c. Finish Coat.

1) Finish coat shall be Tnemec Series 75 (Semi-Gloss) Endura-Shield or approved equal, and shall conform to SSPC-PS Guide 17.00.
2) Finish coat shall be mixed and applied in accordance with the manufacturer's instructions and the minimum dry film thickness shall be 3.0 to 5.0 mils.
3) Total minimum system thickness shall be 8.0 mils.

d. Color: The paint color shall comply as indicated or, if not indicated, as selected by the Government.

e. Finish Quality: Dry paint shall be uniform and continuous with no voids or puddles and shall not be broken by scratches or nicks.

f. Care and Handling: The Subcontractor shall ensure that the painted steel is thoroughly dry and that it is handled carefully to prevent damage to the paint and to reduce field repairs. Nylon slings should be used when handling the painted steel.

g. Certification: Subcontractor shall certify the paint application, including verification of the paint manufacturer's name, paint identification, conformance with manufacturer's written instructions, and the paint dry mil thickness.

F. Source Quality Control:

1. Testing:

a. An independent testing laboratory shall perform testing and inspection of the structural steel and welding.
b. Welds shall be tested by visual, dye penetrant, magnetic particle methods, or ultrasonic methods.
c. Testing laboratory inspector shall be permitted to inspect the work in the shop or field throughout fabrication and erection.
d. The inspector shall check for workmanship of steel, both in the shop and field, and check general compliance with the Contract Documents and shop drawings.
e. Inspector shall record types and locations of all defects found in the work and measures required and performed to correct such defects.
f. Subcontractor shall make all repairs to defective work to the satisfaction of the inspector.
g. Inspector shall submit reports of inspection and test findings to the Government, including records all defects found with subsequent repair operations.
h. The work of the independent inspector shall in no way relieve the Contractor and Subcontractor of responsibility to comply with requirements of the Contract Documents.

G. Product Handling and Protection: Use means necessary to protect structural steel before, during, and after installation and to protect the installed work and materials of all other trades.

H. Rejection and Replacement:
1. In the event of damage to the steel, immediately make all repairs and replacements necessary to the approval of and at no additional cost to the Government.
2. Any materials or welding rejected through inspection either in the shop, mill or field must be promptly replaced to the satisfaction of, and at no additional cost to, the Government.

2.5 FASTENERS

A. Provide fasteners used to secure clamp systems to curbs and cables, assemblage of clamp systems, and other fasteners as required to complete the work specified herein.

B. Materials:
1. All work shall comply with the latest edition of ASTM standards and American Iron and Steel Institute (AISI), as referenced.
2. Fasteners used in membrane clamping systems shall be stainless steel.
3. Bolts and studs shall conform to ASTM F593, alloy group 1, Type 303.
4. Nuts shall conform to ASTM F594, alloy group 1, Type 304.
5. Washers shall be plain, narrow, and conform to AISI Type 304 (18-8).
6. Clamping systems subjected to relative movement between clamping and curb shall receive a split-ring lock washer conforming to AISI Type 304 (18-8).
7. Unless otherwise indicated, other bolts and nuts shall conform to ASTM A307-76B, zinc plated to conform to ASTM B633 Class Fe/Zn 8 type III.

C. Source Quality Control: The manufacturer shall certify that all fasteners comply with the referenced specifications.

2.6 GASKETING

A. Gasketing work shall comply with the latest edition of ASTM standards, as referenced herein.

B. Sponge Neoprene Gasketing: Neoprene gasketing shall be a cellular elastomeric compound of a firm grade manufactured in preformed shapes for use as a gasketing material in accordance with ASTM C509. It shall be homogenous, free from defects and shall be compounded and cured to meet the following ASTM requirements:

1.	Compression Deflection	D105	25% @ 13-24 psi
2.	Compression Set	D395 Method B	30% maximum
3.	Heat Aging	D865 0	Max. 10% change in compression deflection values
4.	Dimensional Stability	C509, Sec. 11.4	4% max. change after heat aging

5.	Ozone Resistance	D1149	No cracks
6.	Water Absorption	D736	5% maximum
7.	Low Temp. Brittleness	C509	Pass
8.	Flame Propagation	C509, Sec. 11.8	100 mm max.
9.	Non-Staining	D925	No migratory stain

C. EPDM Gasketing: Ethylene Propylene Diene Monomer (EPDM) gasketing and flashing shall be non-reinforced, homogenous, free from defects, clean of foreign matter, and shall be manufactured to meet the following ASTM requirements:

1.	Tensile Strength Min. psi	D412	1305
2.	Elongation, Ultimate Min. %	D412	350%
3.	Tear Resistance Min. lbf/inch	D624 (DIE C)	175
4.	Factory Seam Strength Min.	Modified D816	Membrane rupture
5.	Resistance to Heat Aging	D573	
	Tensile Strength min. psi	D412	1200
	Elongation, ultimate min. %	D412	225%
	Tear resistance min. lbf/in	D624	150
	Linear dimensional change, max.	D1204	2%
6.	Ozone Resistance	D1149	No cracks
7.	Low Temp. Brittleness	D746	-75 degrees F
8.	Water Absorption	D471	4% max.
9.	Water Vapor Permeability	E 96	2.0 max. perm-mils (Proc B or BW)
10.	Ultraviolet Weathering		
	Tensile Strength min. psi	D412	1200
11.	Elongation min. %	D412	225%
12.	Sheet Composition	D297	
13.	Weight % of sheet that is EPDM polymer		30% min.
14.	Tolerances:		

a. Thickness shall be plus or minus 10%.
b. Width shall be plus or minus 1/16 IN.
c. Hole spacing (if required) shall be plus or minus 1% of theoretical.

2.7 MAINTENANCE KIT

A. PTFE-Coated Fiberglass Architectural Membrane Maintenance Kit: The Government shall be supplied with the following materials for emergency repair or maintenance. The materials shall be neatly packaged into a maintenance kit for storage by the Government.

Quantity	Description
6	12-inch diameter patch with FEP sheets
12	5-inch diameter patch with FEP sheets
12	4 inch x 8 inch rectangular patch with FEP sheets
6 sq. yds.	PTFE-Coated Fiberglass Architectural Membrane
200 ft.	FEP tape, 3 inches wide
1	Soldering iron, 500w with wedge tip
1	Tacking sealer, 3 inch x 5 inch die
2	Insulating bearing blocks
1	5/8 in. hole punch
1	Utility knife
50	Repair clips
1	Spool of No. 36 nylon twine
36 yds.	Cormar B29/4 x 15 Kevlar® thread
1	Hand awl
1 pkg.	C-29 needles
1	Repair manual

PART 3 - EXECUTION

3.1 ENGINEERING

A. Structural calculations for the project shall be prepared by, or under the direct supervision of, a Professional Engineer registered in the State of Georgia. The responsible engineer may either be a direct employee of the Subcontractor or a qualified consulting engineer.
   1. Based on the structural calculations as defined in this section, prepare structural design drawings which define the completed structure, precise interface geometry determination, definition and coordination with the substructure, reaction loads imposed by the tensile membrane structure, connections, details, interfaces, and seam layout.

B. Structural calculations for the tensile membrane structure shall include the following:
   1. Large deflection numerical shape generation that will insure a stable, uniformly stressed, three dimensionally curved shape that is in static equilibrium with the internal prestress forces, and is suitable to resist all applied loads.
   2. Large deflection finite element method structural analysis of the membrane system under all applicable applied wind, snow and live load conditions.
   3. Finite element method structural analysis of the support frame system.
   4. Member sizing calculations of all primary structural members.
   5. Connection design including bolt, weld, and secondary member sizing.
   6. Biaxial fabric test specification, interpretation, and fabric compensation determination.
   7. Accurate generation of the two dimensional compensated fabric templates required to generate the three-dimensional equilibrium shape.

3.2 FABRICATION OF MEMBRANE PANELS

A. Shop drawings shall include all information necessary for the fabrication of the tensile membrane structure.
   1. Membrane assembly shop drawings shall include size and shape of envelope, type and location of shop and field connections, size, type, and extent of all heat-welded seams.
   2. Subcontractor shall plan and assemble the fabricated sections such that the assembly has no shop patches.
   3. Splices, if any, shall be patterned into a symmetrical and repetitive geometric arrangement within the assembly, shall be shown on the shop drawings and, where feasible, shall be hidden by structural members.
   4. Fabricated joints shall have a minimum of 90 percent of the total strength of the coated membrane in strip tensile testing.
   5. Structural joints shall be fused in accordance with industry standards and shall maintain the integrity of the coating. PTFE-coated fiberglass membranes shall be heat-sealed only.
   6. Biaxial Test: At least one representative sample of the outer membrane shall be biaxially test loaded. Membrane compensation in patterning shall be based upon the results of the biaxial test loading.

3.3 ERECTION OF MEMBRANE ASSEMBLIES

A. Prior to installation of the membrane assemblies, the Subcontractor shall meet with the Contractor to establish the erection procedure and scheduling. The Subcontractor shall coordinate this work with other trades.

B. No trade shall have access to, or work from the membrane, unless authorized by the Subcontractor in writing.

C. Damage occurring during the installation sequence may be temporarily repaired with field patches; however, permanent repairs shall be made with a membrane splice that is symmetrically arranged, or full panel replacement from seam-to-seam or seam-to-approved splice.

D. The Subcontractor shall erect the tensile membrane structure free of any areas where membrane prestress is not induced.

E. Erection of Structural Steel:
   1. The Subcontractor shall employ a competent foreman to supervise all work of steel erection. The foreman shall be present at all times during the Subcontractor's work.
   2. All precautions shall be taken to ensure an accurately located and completely safe and stable structure at all times. Adequate guy cables shall be used throughout the work and all erection bolts shall be drawn up tight.
   3. Steel shall be accurately aligned before permanent connections are made.
   4. Temporary bracing shall be left in place as long as may be required for safety. The bracing shall be located so it does not interfere with the erection of the tensile membrane structure, and can be removed as required during construction.
      a. The structure shall be designed to be self-supporting and stable when fully completed.
      b. It is the Subcontractor's sole responsibility to determine the erection procedure and sequence and to ensure the safety of the building and its component parts during erection.
      c. This includes the addition of whatever temporary bracing, guys or tie-downs that may be necessary.
      d. Such materials shall be removed by the Subcontractor and remain his property after completion of the project.
   5. Erection tolerances shall be specified in the AISC "Code of Standard Practice for Steel Buildings and Bridges", unless otherwise indicated,

3.4 PROTECTION AND CLEANING

A. Protect work from damage and deterioration during installation.

B. Upon completion of tensile membrane structure installation:
   1. The Subcontractor shall clean all surfaces of the system's components in conformance with the membrane manufacturer's recommendations.
   2. Inspect the system and repair membrane panels that have become damaged.
   3. Repairs shall be executed in such a way that they are virtually invisible.

END OF SECTION